A Scanning Target Profile Monitor in the Slow Extracted Beam at the AGS

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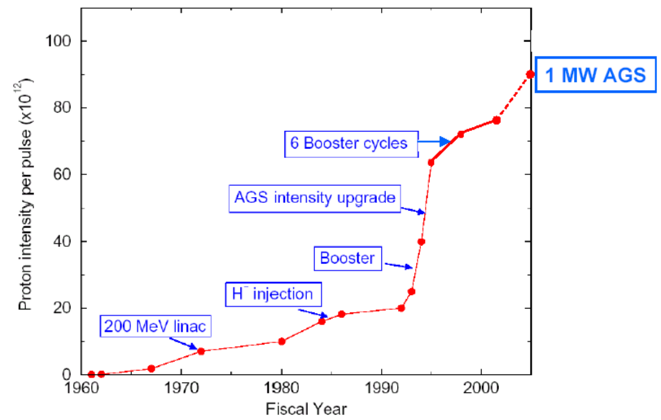
Introduction

Motivation:
Ever increasing proton beam intensity demands.
 Booster injects at higher energy (2GeV vs. 200Mev)
 Now using full AGS acceptance.

As intensity exceeded 1×10^{13} switchyard design
 Beam size increased.
 Causing more halo & losses
 At extraction, beam 2X bigger than before the Booster
 Resonant, slow extraction process.
 150m transport to fixed targets

Existing diagnostics: BLM's suffered from high background
 Phosphor screens/video lacked dynamic range

AGS Intensity History



World record proton synchrotron intensity!

Device: Prototype Scanning target
- Scattering into two scintillator telescopes, triple coincidence
- Secondary emission from thin targets
- Targets are movable over the entire 4" aperture

Purpose:
Routinely measured slow extracted beam emittance.
Diagnostic for probing the wings of the beam distribution.

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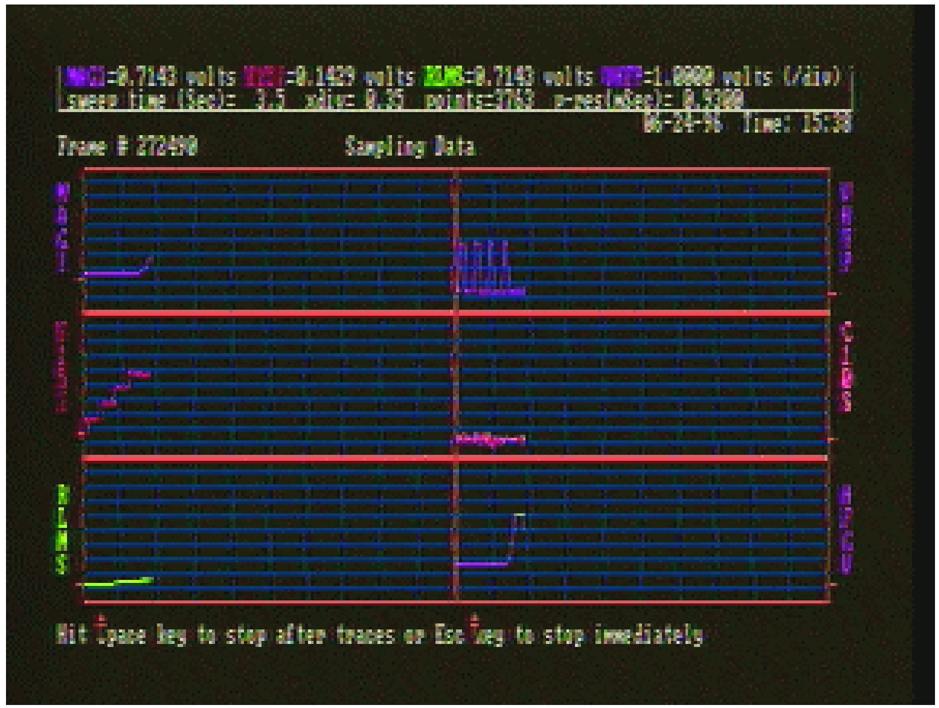
Machine Cycle



60×10^{12}, one second spill = 10uA average beam-on current

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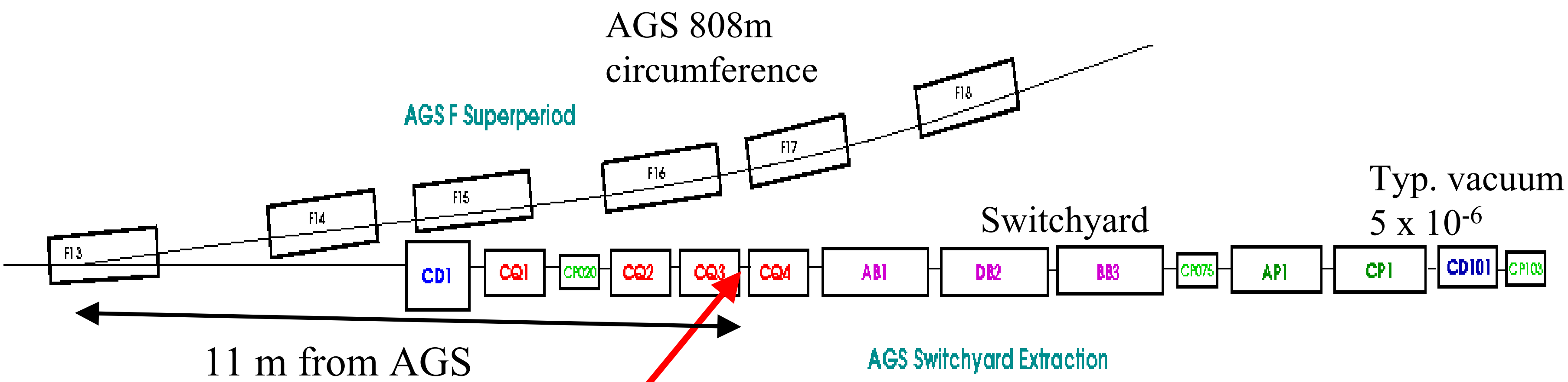
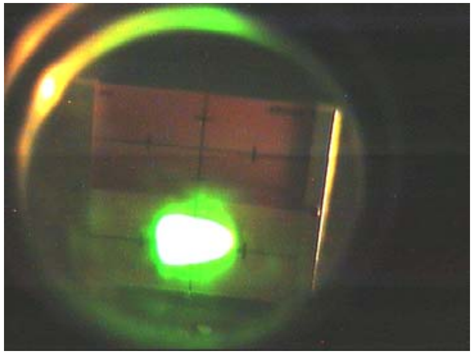
Slow Extracted Beam Transport Layout

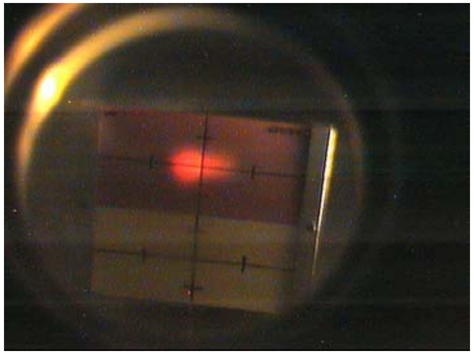


Scanning Target
installed here

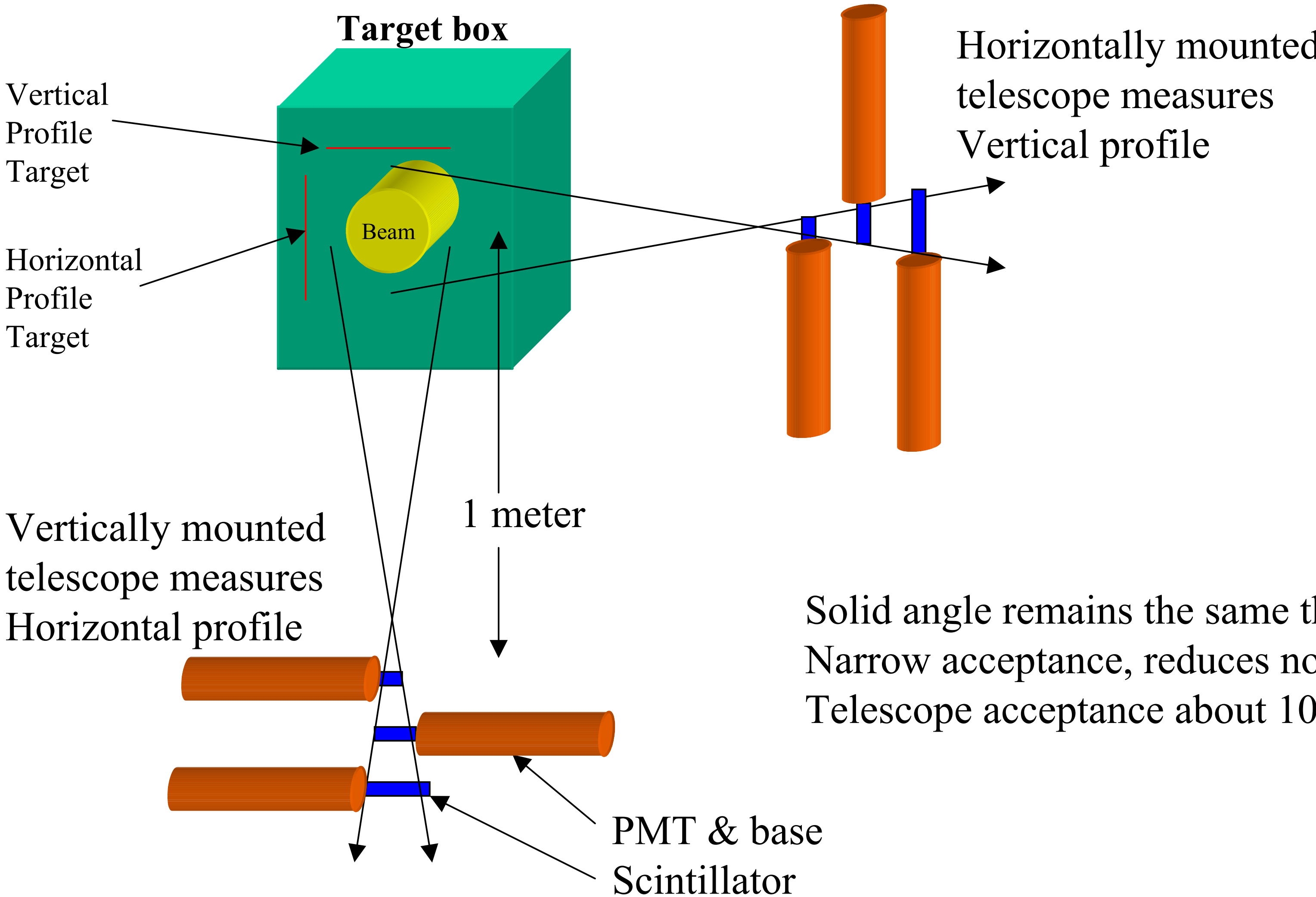
Radlin screen



AlOx screen



Telescope Operation



Solid angle remains the same through scan
Narrow acceptance, reduces noise.
Telescope acceptance about 10^{-4} steradian.

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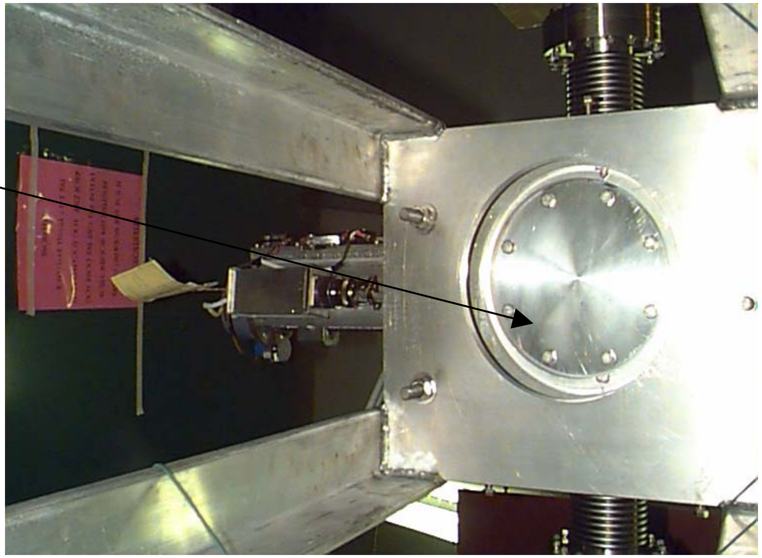
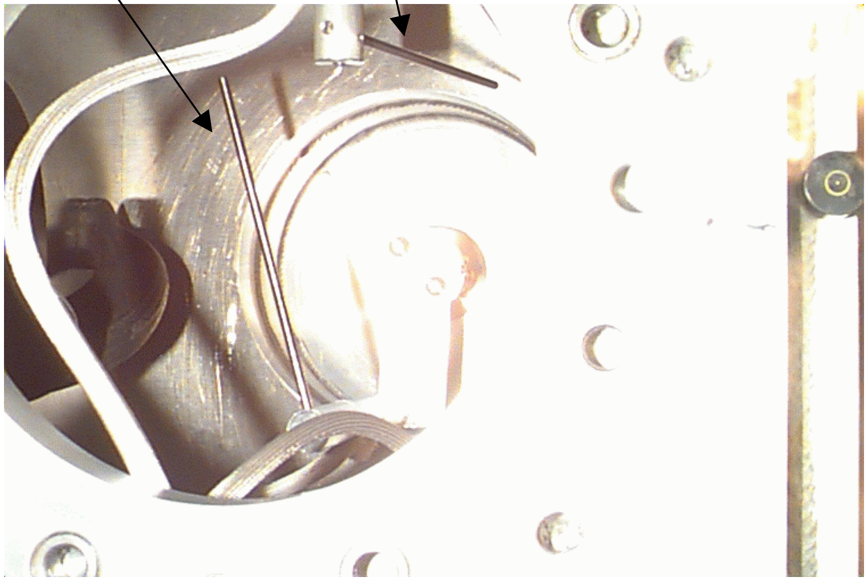
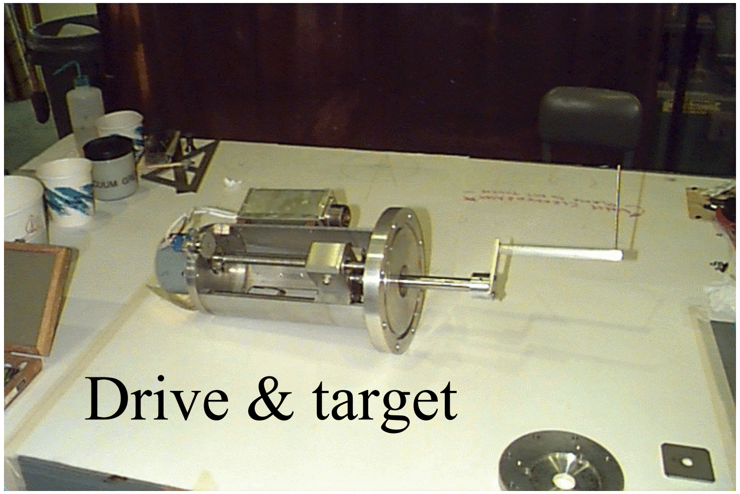
Target Box

Thin Aluminum ports for 90^0 scattering.



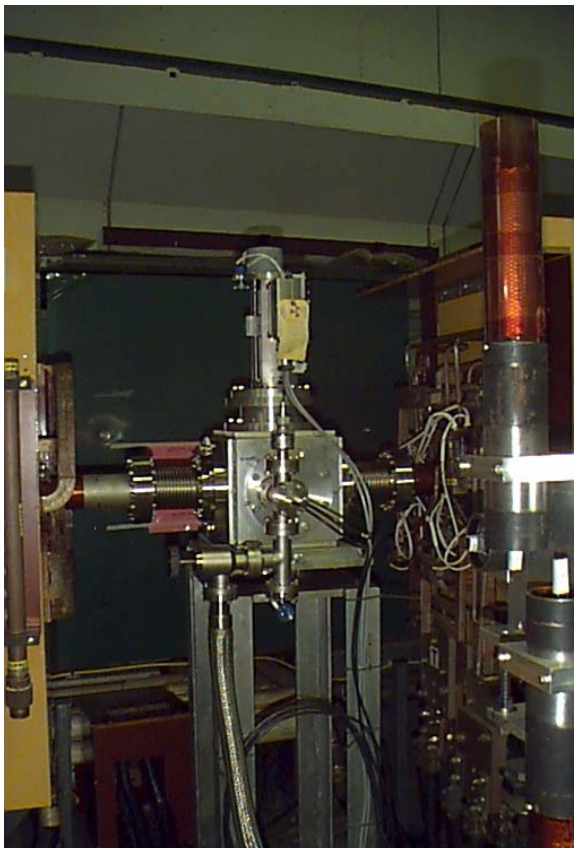
Tungsten targets, 2.5mm



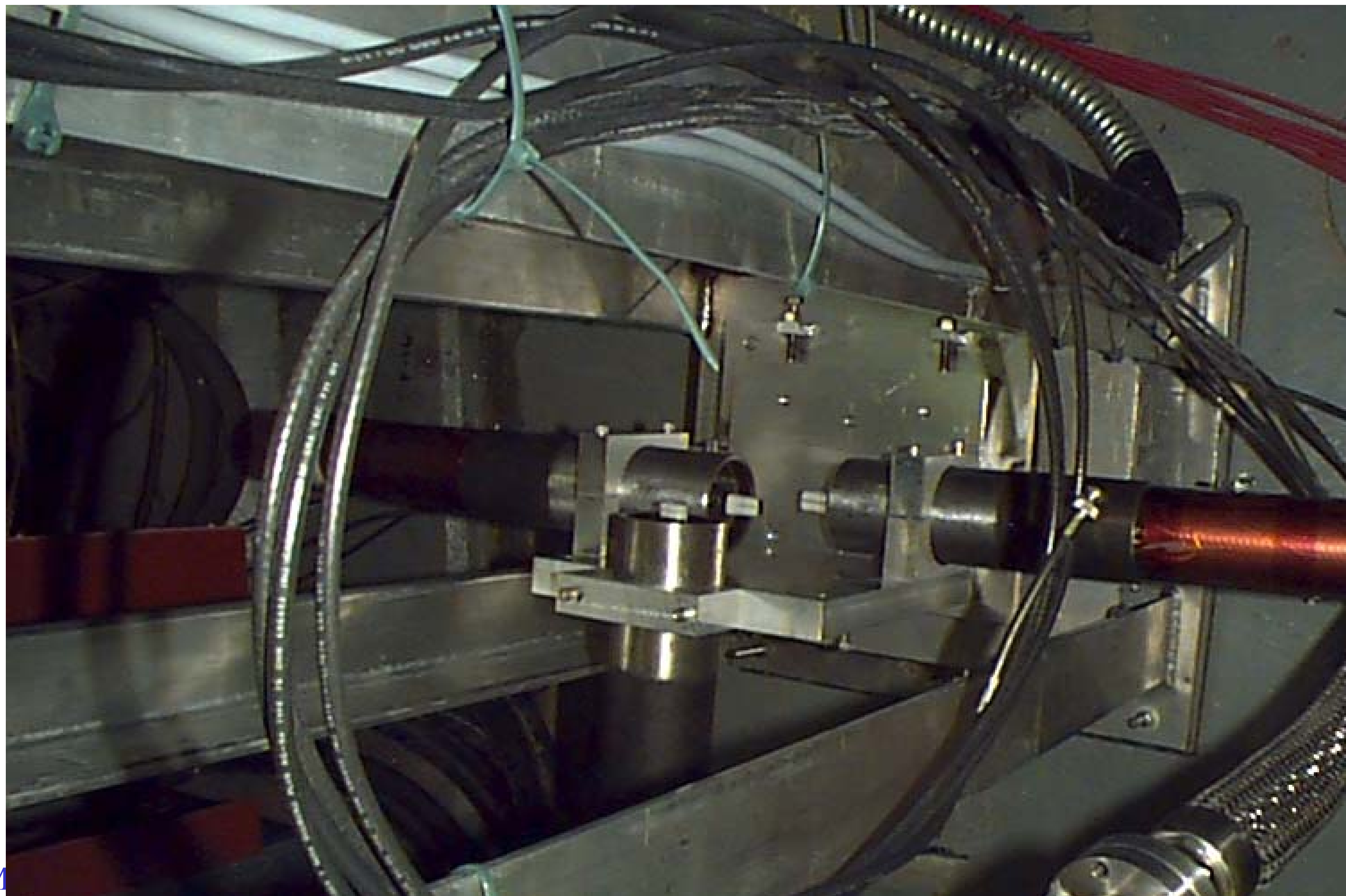


Drive & target

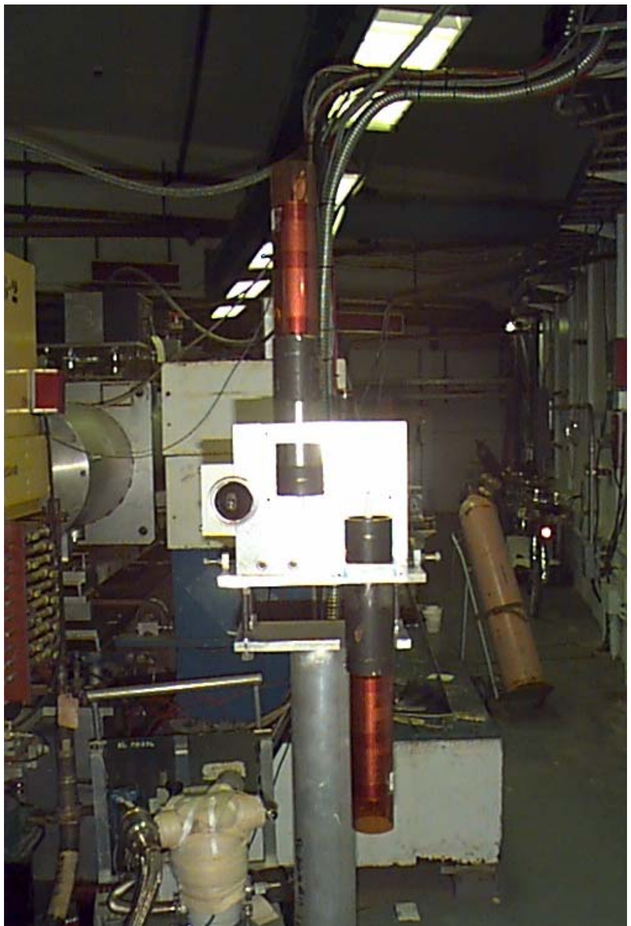
Beamline Assembly

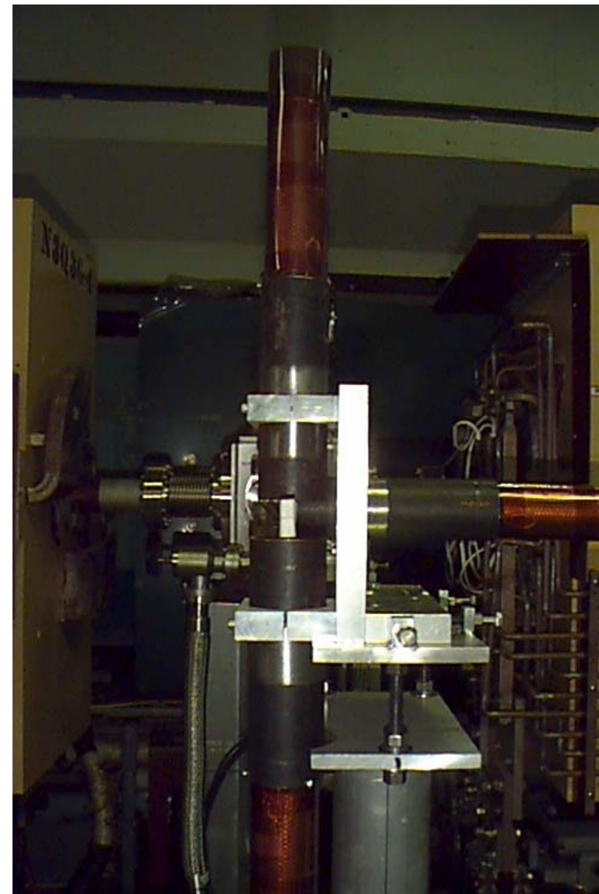


Horizontal Telescope



Vertical Telescope





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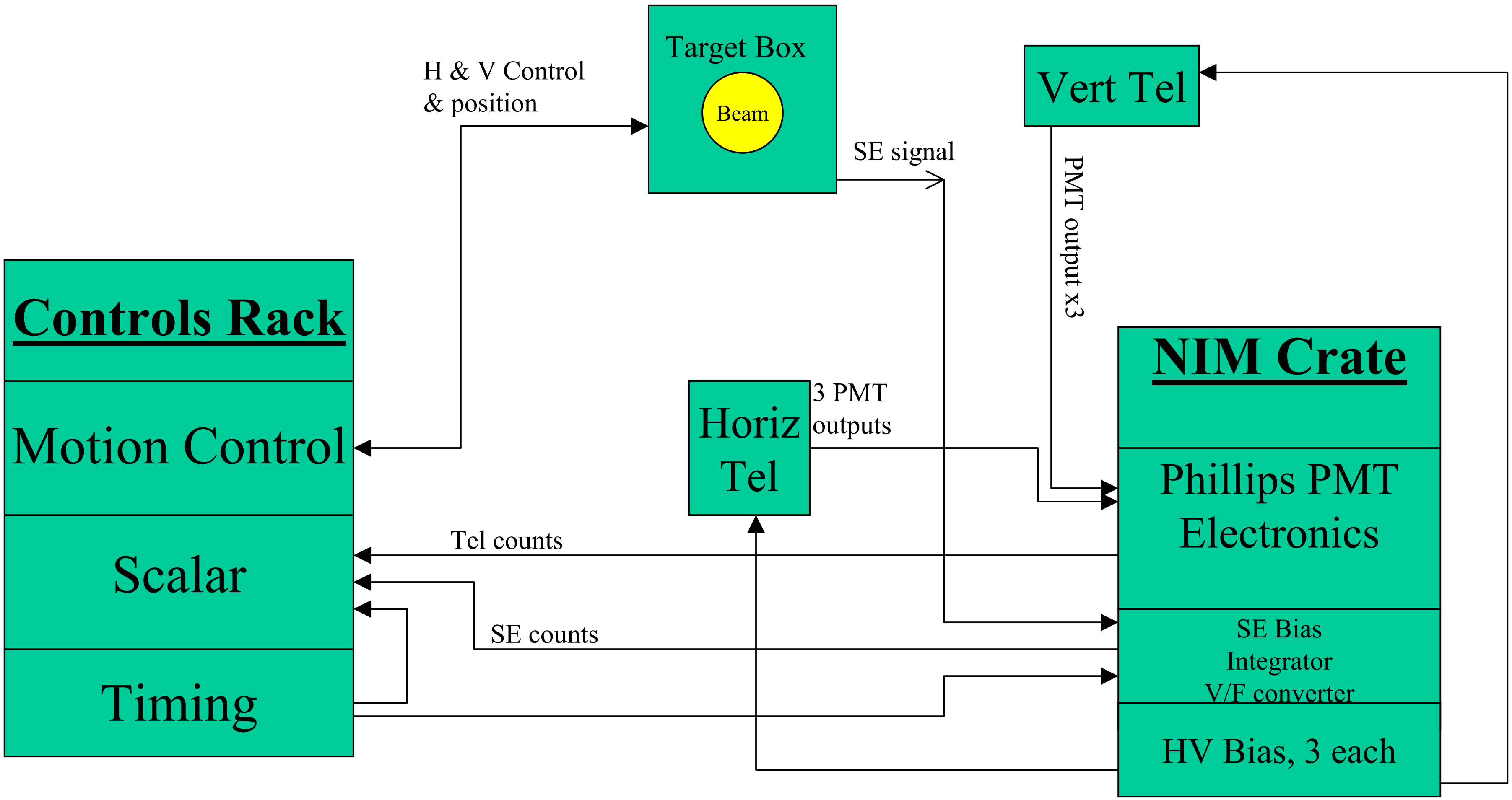
System Block Diagram



System Components

Telescope

- Scintillator - Bicron BC404
- PMT - Electron Tubes, Inc. 9813Kb
- BNL designed base, 14 stage, passive
    - Typical pulse FWHM 10ns
- Mu-metal shield, stray fields <10 gauss

NIM Electronics

- Phillips Scientific
    - 770 Amplifier x10
    - 704 Discriminator
    - 754 Coincidence
    - 726 Level converter
- Scalar

Secondary Emission

Isolated, biased target

Gated integrator, 1000pF

V/F Converter, 1000 Counts/V

Scalar

Telescope & Secondary Emission Data

Telescope Triples

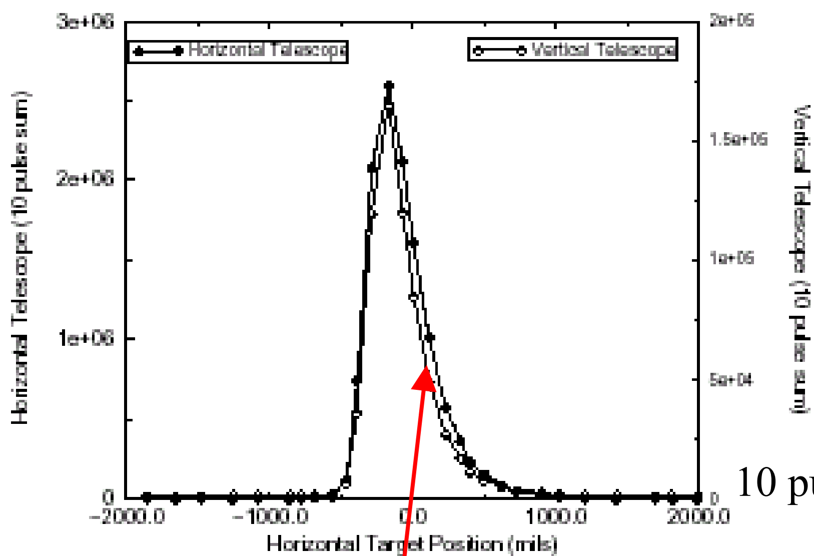


Figure 1: Horiz. and Vert. Telescope triples for Horz. scan

Error by viewing wrong telescope

Secondary Emission data

10 pulse sum data

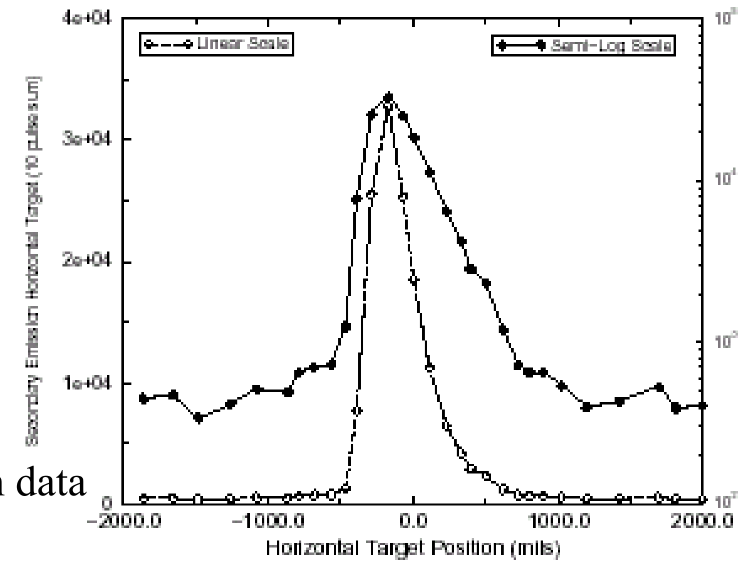


Figure 3: Secondary Emission from target for Horz. Scan

Estimate beam on target intensity at profile peak, SEM signal.
3V on 1nF = 3nA (1 sec spill) X 25(SE%) = 75nA
5e11 protons/sec = 80nA
Beam current 2.5e12 = 400nA

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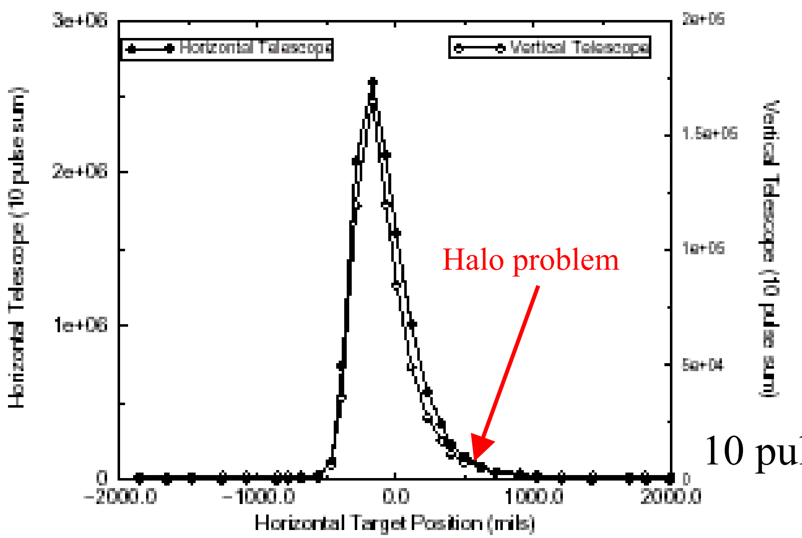
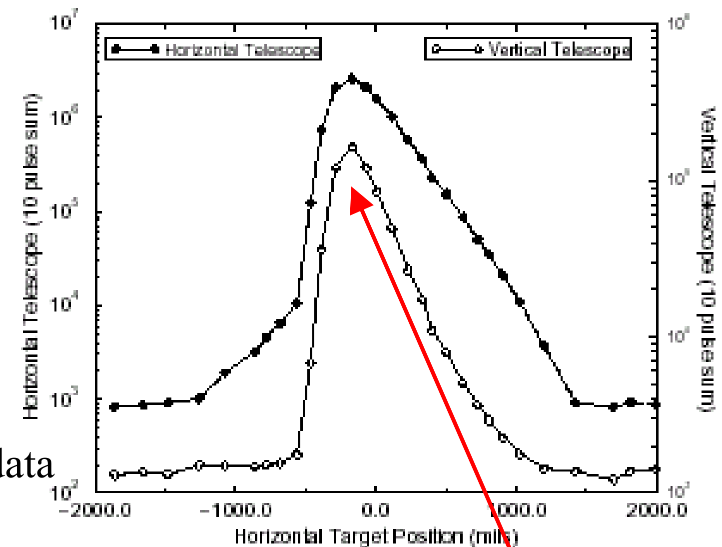
Horizontal Scan, Telescope Data

Linear scale



Log scale



10 pulse sum data

FWHM approx 1.2cm

Figure 1: Horiz. and Vert. Telescope triples for Horz. scan

Figure 2: Horz. and Verti. Telescope triples for Horz. Scan

Measurement shown above, about 10 times below saturation threshold.

S/N 66dB, can resolve 0.05%, DR > 10^3 to 10^4

Beam current 2.5e12/sec	400nA	
Noise floor, 1k		
Peak 200k, 5e11	75nA	Singles rates at peak 5M/sec
+500mils 10k, 2.5e10	4nA	
+1000mils 2k, 2.5e9	0.2nA	

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Results

Table 1: Summary of emittance measurement results.

(note: β and α are referred to start of SEB line)

	$\epsilon_x^{95\%,N}$	β_x *(m)*	α_x	$\epsilon_y^{95\%,N}$	β_y *(m)*	α_y
FY82	31.9	57.6	-6.6	38.8	3.25	0.87
FY96	64.4 ± 9.60	8.8 ± 1.4	-0.9 ± 0.2	54.7 ± 5.0	4.2 ± 0.4	1.0 ± 0.09

Measurements show a factor of 2 increase as a result of Booster injection.

Halo reduction and understanding gets more critical as intensity increases.

Summary

Scanning target profile monitor proved useful.

Halo problem solved by positioning the extraction kicker and ejection septum further to the inside of the AGS, causing the beam to spend less time in the fringe and edge fields of the AGS main magnets.

Scanning target has since been replaced with current transformer.

Beam profile measurement dynamic range:

Telescopes	4 to 5 orders
SEM	2 to 3 orders
Good agreement	

Intensity limitation on measurement.

At higher intensities see evidence of saturation.

- high singles rates > 40M/sec
- profile flattening

Improve performance by optimizing (reducing):

Target size

Solid angle acceptance of telescope